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RURAL TRANSFER AND MODIFIED LANDFILL. A COMPARISON OF COST INDICATORS FOR LOW VOLUME RURAL SOLID WASTE DISPOSAL METHODS

Oregon University
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December 1973

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One of the key considerations in selecting a system of solid waste management is the relative costs of the available alternative systems. This report was prepared in order to provide public officials and solid waste management planners with information upon which they can base estimated costs of operating a rural transfer system as well as a modified landfill system. The suggested estimating techniques are compatible and permit comparison of the estimated costs of these two alternative management systems. The experience of the Lane County, Oregon Solid Waste Division provided the basis for development of the cost estimating techniques outlined in this report.

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RURAL TRANSFER AND MODIFIED LANDFILL

A COMPARISON OF COST INDICATORS FOR LOW VOLUME RURAL SOLID WASTE DISPOSAL METHODS

An Information Reference Report

Prepared for the Solid Waste Division
Department of Environmental Quality

By the

BUREAU OF GOVERNMENTAL RESEARCH AND SERVICE
University of Oregon

OREGON STATE DEPARTMENT OF ENVIRONMENTAL QUALITY
1234 S.W. Morrison
Portland, Oregon

December 1973

FOREWORD

One of the key considerations in selecting a system of solid waste management is the relative costs of the available alternative systems. This report was prepared in order to provide public officials and solid waste management planners with information upon which they can base estimated costs of operating a rural transfer system as well as a modified landfill system. The suggested estimating techniques are compatible and permit comparison of the estimated costs of these two alternative management systems.

The experience of the Lane County, Oregon Solid Waste Division provided the basis for development of the cost estimating techniques outlined in this report. Similarly, examples of the application of these techniques utilize the Lane County operation as a frame of reference. However, the techniques have been generalized and described, and with appropriate modification to account for local conditions they can be used by others for estimating the costs of similar systems elsewhere.

In applying the estimating techniques to meet the needs of Lane County, the estimated annual operations cost for a twelve-station rural transfer system was $161,000. Depreciation of drop boxes and amortization of site improvements resulted in an estimated total annual cost of $176,000. A modified landfill system operated by roving crews and involving at least once-per-week cover was estimated to cost $130,000, exclusive of amortization of site development costs. In this connection, it may be appropriate to note that the modified landfill system very often will be less costly than the rural transfer system but that the quality of service usually will be higher and more consistent under the transfer system. In addition, as landfill sites become increasingly scarce or as a full sanitary landfill (with daily cover) becomes necessary to meet environmental quality goals, the rural transfer system becomes more attractive for situations involving relatively low waste volumes and scattered settlements.

This report and the techniques described in it were developed by A. Mark Westling and J. David Rowe, staff members of the Bureau of Governmental Research and Service, University of Oregon, as part of a solid waste management information program financed by the Oregon State Department of Environmental Quality. Basic information concerning the Lane County operations was provided by Bruce B. Bailey, director, Lane County Solid Waste Division and his staff. James Benten of that office made the cost calculations applying the modified landfill alternative and also made the estimate of relative fuel demands of the two systems.

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I. RURAL TRANSFER OPERATION

THE LANE COUNTY EXPERIENCE

Lane County's solid waste management planning and implementation program includes a program to substitute transfer stations for the rural refuse disposal landfills in the county. The typical rural landfill consists of a trench or bank over which local citizens dump their solid waste. Sufficient trench for a year's operation is excavated at one time during a period of favorable weather. The site is visited periodically by a roving county crew which uses a bulldozer to push the waste from the immediate dumping location to one end of the trench or bank. The material is compacted and covered. The frequency of visits varies somewhat between sites and seasonally, depending upon the volumes of waste received at the various landfills.

The cost of these rural landfills has increased annually as the operations were improved. Complete elimination of systematic burning at these sites, accomplished in July 1971, resulted in higher operating costs ($83,700 in 1971-72 as compared with $65,400 in 1970-71), did not solve many of the problems inherent in these landfill operations, and, in fact, may have contributed to the intensification of other problems. Elimination of burning apparently increased problems due to leachate, and the expense of landfill operations will increase further if leachate production is to be corrected.

The State Department of Environmental Quality's standards for issuance of solid waste disposal site permits include other requirements that will further increase operating costs. Nearly all of the unattended sites require reconstruction work or need to be relocated. Surface drainage control and leachate holding ponds will need to be constructed. In addition, a fire watch would be desirable at certain sites during the height of the fire season.

Based on an evaluation of each existing site, costs necessary during the 1972-73 year were estimated at $109,000. The estimate was a judgment based on a probable minimum level of operation likely to be acceptable to the Department of Environmental Quality. However, there was no assurance that this program would be satisfactory for any extended period. For example, no specific program to resolve leachate problems was included other than the construction of small holding ponds and the expectation that the problem could be reduced somewhat by improved operations that would reduce the amount of water seeping through the refuse. Other cost increases can be anticipated in future years as environmental quality standards become more fully established. Conversion of the sites to sanitary landfills would involve a substantial additional expenditure.

A Transfer System: Background

As an alternative to the continued investment in low volume rural disposal sites, the county is shifting to a system of drop boxes. Under this technique, rural landfills are being closed and the refuse is collected in drop boxes which are hauled to major regional disposal sites. Full-time operation of the regional sites provides greater opportunity to conduct a satisfactory sanitary landfill. The increase in volume handled at the regional sites will reduce the unit cost of operation and provide for a more effective operation.

The least active of the 13 rural landfills operating in Lane County in 1972 received less than 2,000 cubic yards of waste. The most active received over 30,000 cubic yards. The 117,000 cubic yards of waste coming to these sites represents less than 7 per cent of the waste coming to all county disposal sites. Good information is not available on seasonal variations in the volumes received, but the differences in quantities received during the low use months and the high use months is significant and has an effect on the design and operation of transfer stations to replace the landfills.

The first three rural drop box transfer stations have replaced the landfills known as London (3,959 cy), Vida-Leaburg (8,189 cy), and Disston (4,268 cy). The transfer stations are as follows.

Name	Opening Date
London	January 5, 1973
Vida-Leaburg	February 21, 1973
Sharps Creek	May 26, 1973

Each transfer station is constructed to provide a wall along which 45 cubic yard containers are spotted. The users of the disposal facility dump directly into the boxes. Two boxes are left at the site at one time by a truck-trailer combination capable of hauling both boxes on one trip. The sites are designed so that two empty boxes can be put in place and two full boxes removed by handling each box only once. (See Figure 1.)

The costs involved in the transfer station operation can be divided into three general categories: (1) capital outlay for site development, (2) capital outlay other than site development, and (3) operations and maintenance.

Site Development Costs

The first three Lane County sites were developed at a total cost of $36,477.80 as shown in the tabulation below:

Materials	$12,047.16
Labor, equipment	21,368.31
Engineering	3,062.33
TOTAL	$36,477.80

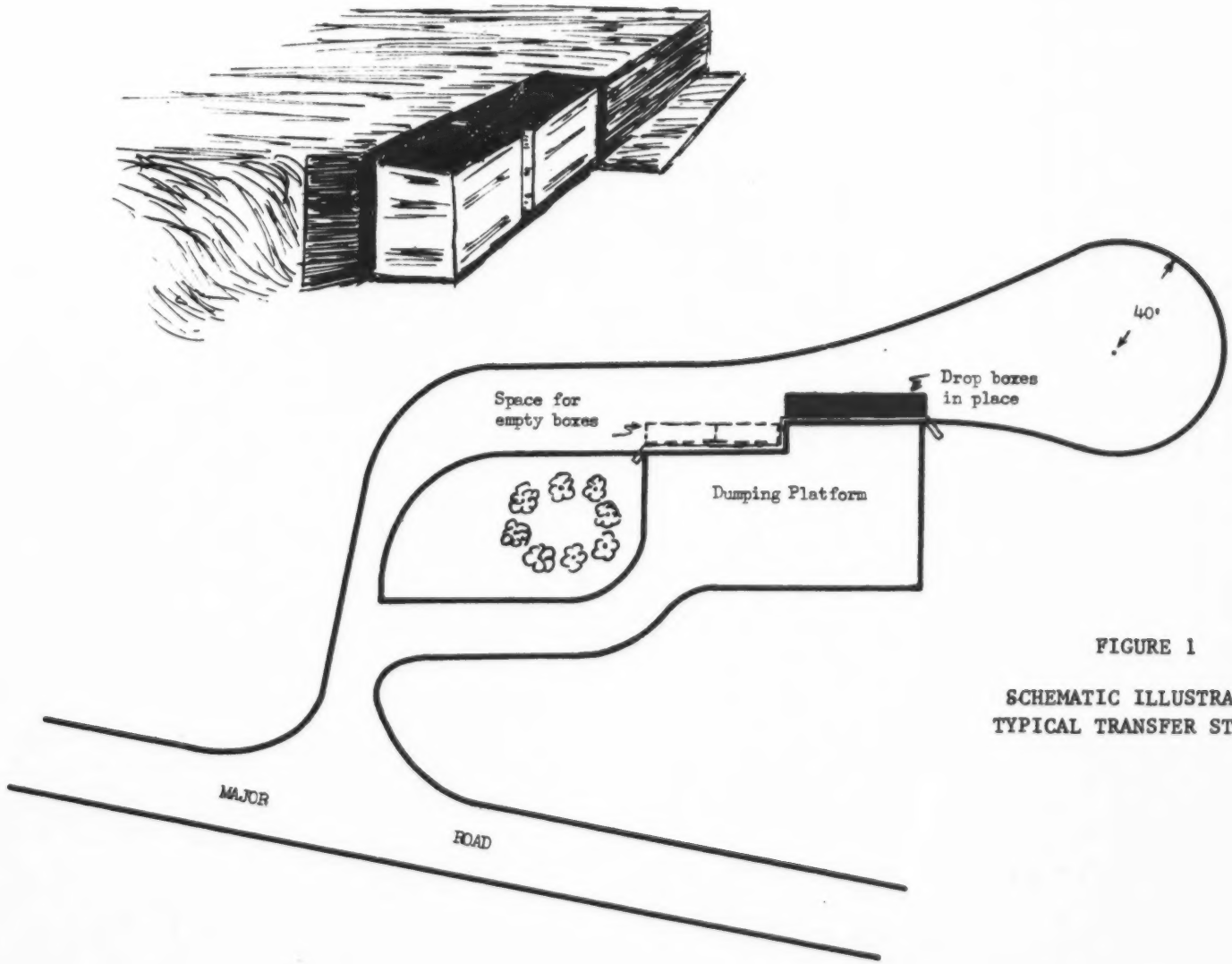


FIGURE 1

SCHEMATIC ILLUSTRATION
TYPICAL TRANSFER STATION

A detailed itemization of the costs is presented in Table 1. During this period, some amount of experimentation has been necessary. It is anticipated that additional sites of comparable size will cost about $10,000. As would be expected, there is variation due to the physical ground characteristics at each site. The sites are being constructed so that they can be used over an extended period of time without much additional cost. If, for some reason, a particular site should prove to be poorly located to meet future needs, substantial portions of the materials can be salvaged for reuse at another site. These costs do not include the expense of locating and acquiring the land for the site.

Table 1

TRANSFER STATION SITE DEVELOPMENT COST[1]
(Excluding Land Cost)

Item	London Site	Vida Site	Sharps Creek Site
Engineering Costs	$ 626	$ 461	$ 1,902
Materials			
Lumber	22	28	794
Rock, Misc. Concrete	144	1,809	166
Steel	856	1,317	1,503
Misc. Hardware	12	73	30
Core Floor	1,550	1,860	1,880
Labor			
Form Work, Concrete	1,067	1,333	1,157
Other Labor[2]	5,969	8,727	4,085
Signing	24	49	--
TOTAL SITE DEVELOPMENT	$10,270	$15,657	$10,551

1. Rounded to nearest whole dollar. May not total due to rounding.
2. Includes miscellaneous materials and equipment costs.

Source: Solid Waste Division, Lane County Public Works Department.

Other Capital Outlay Costs

Major capital outlay other than for development of the transfer station sites consists of the specialized equipment required for the transfer operation. This equipment includes the drop boxes and a truck consisting of a tractor unit and a special semi-trailer unit. The truck with its trailer serves to haul and load and unload the drop boxes.

Cost of tractor unit	$21,219
Cost of semi-trailer unit	25,571
Cost of drop box	1,713

Each transfer station requires two drop boxes and must share in the cost of any additional boxes. Each transfer station's cost therefore will include the cost of 2.5 boxes when the entire Lane County program is in effect. The cost of drop boxes per station will be $4,282.50. The boxes are expected to last at least five years.

One trailer unit is expected to service five transfer stations. A minimum of two trailer units is desirable to permit flexibility of operations and to guard against problems during periods of equipment maintenance.

The capital outlay needs are significant and must be taken into account in developing a financing program. A rural transfer system requires an initial investment in specialized equipment and sites, and the total system should be put into effect within a short time period, otherwise equipment will be only partially used and trip scheduling will be incomplete. Budgeting a major outlay of funds over a one or two year period will be required.

To provide a total cost picture for cost comparison purposes, capital outlay should be amortized over an effective life, and the annual cost for this amortization should be added to the annual "out-of-pocket" expense of operating the system.

Operations and Maintenance Costs

The operation of the transfer system consists of two basic procedural components: (1) travel to and from the transfer station and (2) loading at the station and unloading at the landfill. Both components involve elements of labor and equipment costs. In addition, site maintenance operations (road grading, minor repairs, etc.) and contingencies (fire control or supression, etc.) also contribute to the total cost of the system.

A Transfer Site Analysis Sheet has been prepared to assist in predicting the total annual cost of each rural drop box transfer location. (See Figure 2.)

FIGURE 2

TRANSFER SITE ANALYSIS SHEET

a. Distance from site to regional sanitary landfill _____ miles

b. Average haul speed _____ MPH

c. Travel time, round trip [2(a) ÷ b] _____ hours

d. Load-Unload time _____ hours

e. Total time, per trip [c + d] _____ hours

f. Hourly cost $_____ per hour (including any overhead)

g. Cost per trip [e x f] $_____

h. Volume of waste (annual) _____ cy

i. Capacity of boxes hauled per trip _____ cy

j. Percentage full average box _____ %

k. Volume of waste per trip [i x j] _____ cy

m. Number of trips per year [h ÷ k] _____ trips

n. Annual cost all trips [g x m] $_____

p. Other operational costs (routine) $_____

q. Other operational costs (contingency) [n x ___%] $_____

r. Disposal unit cost $_____ per cy

s. Disposal cost [h x r] $_____

t. Total annual cost--operations [n + p + q + s] $_____

u. Transfer box annual depreciation $_____

v. Site development annual amortization $_____

TOTAL ANNUAL COST [t + u + v] $_____

Transit Time

As shown in Table 2, the Lane County experience indicates that the transport tractors and trailers average a speed of about 33 miles per hour. The data in the table also indicates that the average speeds increase in proportion to the distance of haul (see Figure 3), and that average speed is also noticeably affected by predominant grade.

Ordinarily the haul distance will be the round trip distances from the drop box site to the regional landfill, but there may be scheduling exceptions at the beginning and end of the day.

Loading and Unloading

The time required for loading and unloading drop boxes varies considerably depending upon circumstances peculiar to each day's operations. Equipment malfunction, flat tires, over-full boxes, and other similar conditions need to be accounted for. The Lane County drivers' log books indicate that after initial adjustments to the system, the loading operation (including the unloading and placement of empty boxes at the site) required about 45 minutes, although it has been accomplished in as little as 20 minutes and has frequently taken an hour or more. Unloading at the regional landfill seldom takes less than 30 minutes nor more than one hour, with an average of between 35 and 45 minutes. Loading and unloading times logged by the Lane County drivers are graphically illustrated in Figures 4 and 5 and are summarized in the tabulation below:

Month	Loading Time (minutes)			Unloading Time (minutes)		
	Average	High	Low	Average	High	Low
February	70	100	50	56	75	35
March	63	90	40	55	80	30
April	59	105	30	46	60	30
May	42	75	20	40	55	15
February-May	54	105	20	46	80	15

In Lane County, standard hourly charges for each piece of equipment have been established by the county's motor pool. The cost of the tractor and trailer are billed to the solid waste division at $8.50 per hour, a figure that includes a depreciation reserve as well as gas, oil, insurance and vehicle maintenance costs. When the cost of the equipment operator and overhead are added to the equipment rental charge, the total hourly cost of the transfer vehicle operation amounts to $14.79.

Equipment rental	$ 8.50/hour
Equipment operator	4.66/hour
Overhead[1]	1.63/hour
TOTAL HOURLY COST	$14.79/hour

1. Overhead represents 35% of labor charge and includes employe fringe benefits plus costs of general supervision.

Table 2

TRANSIT TIME AND AVERAGE SPEED
LANE COUNTY TRANSFER STATION OPERATION
February-May 1973

Origin-Destination	Distance in Miles	Number of Trips	Total Mileage	Transit Time (hours)	Average Speed (MPH)
Day Island-Vida					
Empty	24	57	1,368	41.583	32.9
Loaded	24	50	1,200	33.666	35.6
Day Island-London					
Empty	36	15	540	14.750	36.6
Loaded	36	3	108	2.916	37.0
London-Cottage Grove					
Empty	15.5	12	186	7.000	26.6
Loaded	15.5	26	403	17.083	23.6
Cottage Grove-Vida					
Empty	48	3	144	3.416	42.2
Loaded	48	11	528	12.416	42.5
TOTAL, AVERAGE					
Empty			2,238	66.750	33.5
Loaded			2,239	66.083	33.9

Source: Lane County Solid Waste Division drivers' logs.

FIGURE 3

AVERAGE HAUL SPEED IN MPH BY DISTANCE OF HAUL
(Adapted from Lane County Data)

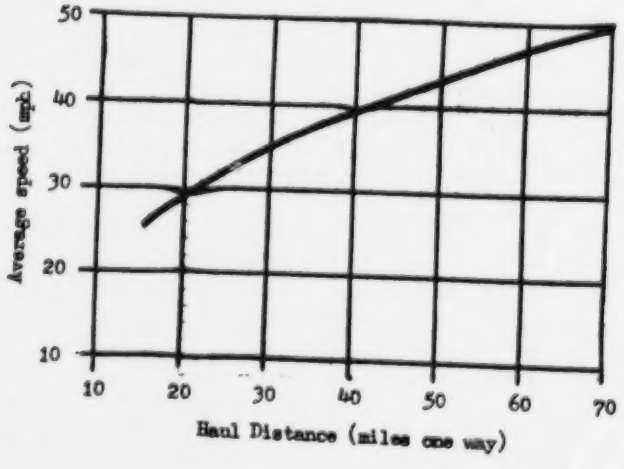


FIGURE 4

LOADING TIME
LANE COUNTY TRANSFER SYSTEM

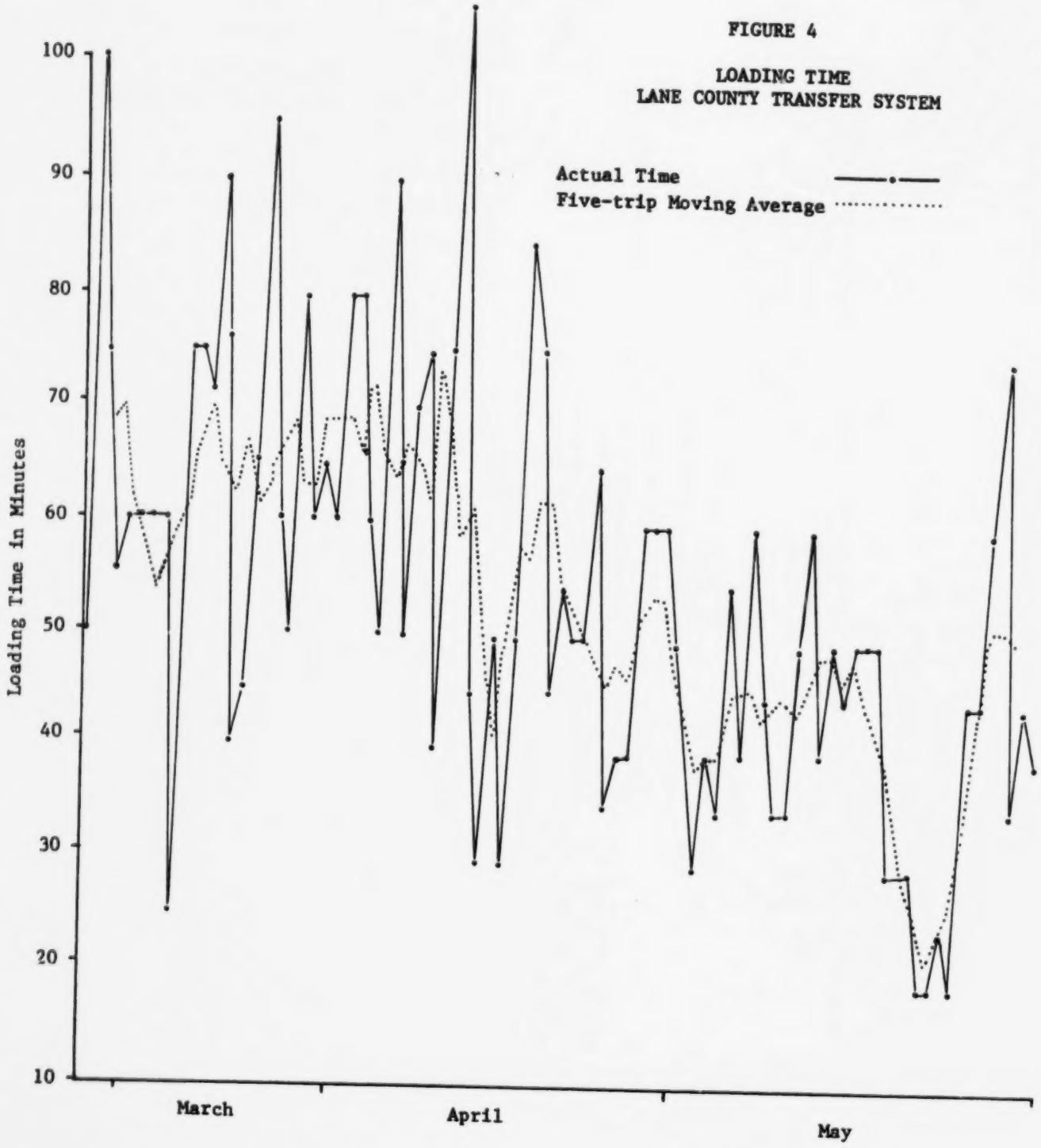
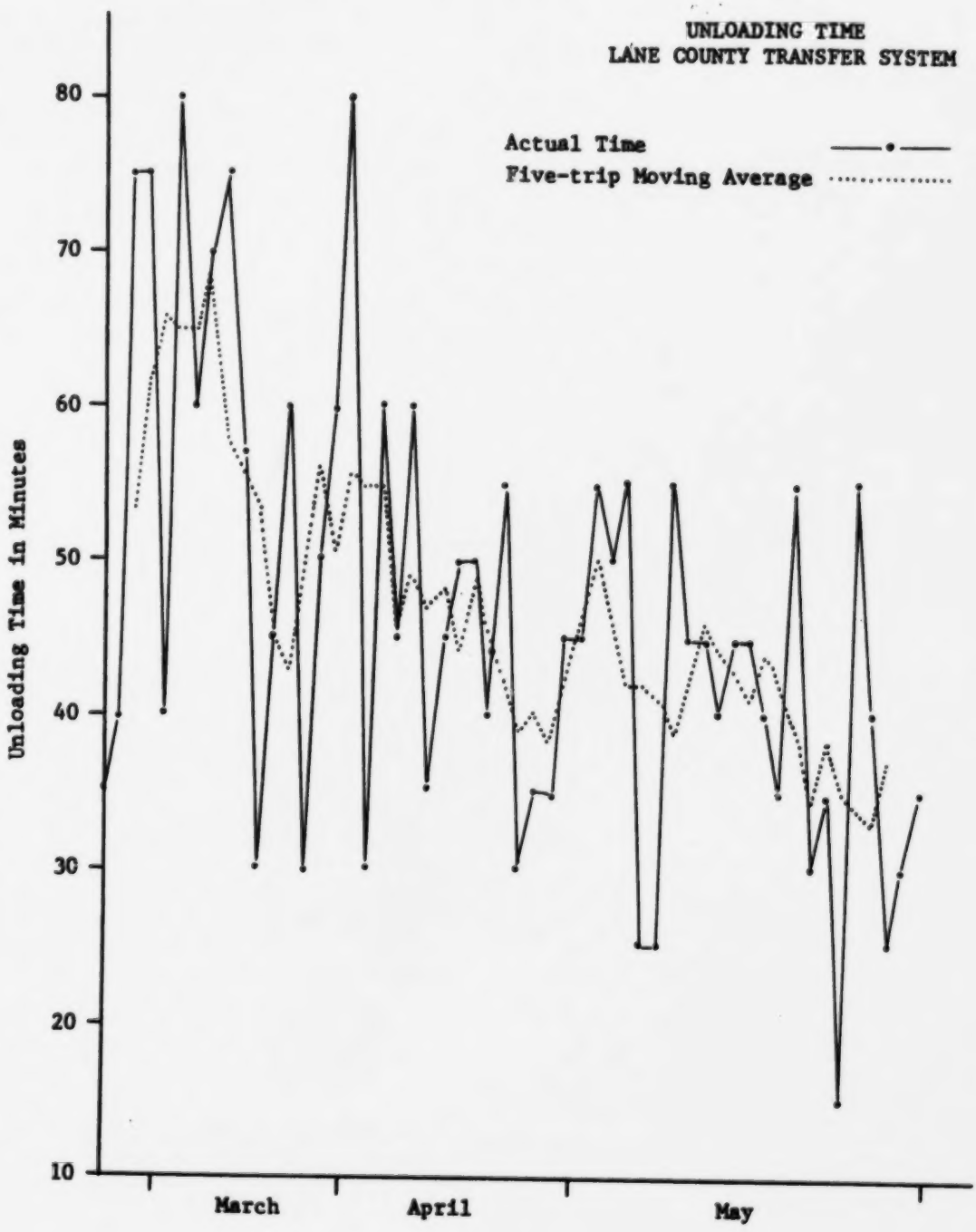


FIGURE 5

UNLOADING TIME
LANE COUNTY TRANSFER SYSTEM



Site Maintenance and Contingencies

Routine site maintenance will consist of roadway repair and occasional replacement of a stop-log or flap. These costs have been estimated at $250 per site per year. Various problems will arise and an allowance must be made for contingencies. Most probable contingency costs will be due to a fire occuring in a drop box or an equipment breakdown. The contingency cost is estimated at 10 per cent of the transfer vehicle operation cost. As experience is gained, this figure may prove to be greater than necessary.

Volumes Handled

The first three full months' operation at the London and Vida sites indicates that annual volumes of 7,360 and 15,620 cubic yards, respectively, can be anticipated:

Month	London	Vida
March	520cy	1,125cy
April	720	1,355
May	600	1,425
3-Month Total	1,840cy	3,905cy
Annual Estimate	7,360cy	15,620cy

During the three months, March through May, 27 trips from the London site and 56 trips from the Vida site were made. Each trip could handle a total of 90 yards of waste material, and although a number of hauls were 100 per cent of capacity, the average haul was a little more than 75 per cent of capacity, as shown in Table 3.

Table 3

WASTE VOLUME HAULED AND VOLUME HAULED AS PER CENT OF CAPACITY
Two Lane County Transfer Stations, March-May 1973

Month	Number of Trips	Cubic Yards Hauled		Yards Hauled as % of Capacity		
		Total	Average	Average	High	Low
London Transfer Station						
March	7	520cy	74.3cy	82.6%	100.0%	44.4%
April	11	720	65.5	72.8	100.0	44.4
May	9	600	66.7	74.1	100.0	50.0
3-Month Total	27	1,840cy	68.2cy	75.8%	100.0%	44.4%
Vida Transfer Station						
March	14	1,125cy	80.4cy	89.3%	100.0%	55.6%
April	19	1,355	71.3	79.2	100.0	50.0
May	23	1,425	62.0	68.9	100.0	27.7
3-Month Total	56	3,905cy	69.7cy	77.4%	100.0%	27.7%

Source: Records of Lane County Solid Waste Division.

Transfer System Costs: Some Generalizations

The unit costs of operating a transfer system given in Table 4 and depicted in Figure 6 were developed from information presented in the preceeding sections, and in accordance with the technique summarized in Figure 1.

As indicated by the data presenced in Table 4 and Figure 6, the unit cost of the transfer system increases markedly for stations with volumes of less than 4,000 yards annually. In addition to the relatively greater ratio of fixed costs to total costs at the lower volumes, a major factor contributing to these higher unit costs is the need to remove waste at least once per week. Under these conditions, the boxes frequently will be less full than otherwise would be the case.

The data presented in Table 4 and Figure 6 also suggests that in transferring waste from stations receiving over 25,000 cubic yards annually, the unit cost will approximate $0.72 plus $0.007 per mile of one-way distance between the transfer station and the disposal site. For example, the unit cost of transporting waste from such a station located 35 miles from a disposal site would be about $0.97 [$0.72 + (35 x 0.007)].

Preliminary evaluation of scheduling problems suggest that, for sites likely to receive 30,000 or more cubic yards per year, the alternative use of a compacting system in order to increase the payload to a maximum allowable weight (and thereby reduce the number of trips required to service these more heavily used stations) should be evaluated.

The unit operating cost data presented in Table 4 and Figure 6 include the following:

1. Costs associated with loading, hauling and unloading the drop boxes;
2. Disposal cost at the regional sanitary landfill;
3. Routine site maintenance (repairs, road grading, etc.); and
4. Contingencies (fire, equipment malfunction, etc.).

The unit operating costs do not provide for the costs associated with depreciating the drop boxes or with amortizing the transfer station site improvements. Appropriate proportions of these capital costs should be added to the figures presented in order to obtain a more complete estimate of total costs.

Table 4

OPERATING COST[1] PER YARD BY VOLUME AND LENGTH OF HAUL
Rural Transfer System

Annual Volume	Length of One-Way Haul (in miles)							
	10	15	20	25	30	40	50	60
2,000cy[2]	$1.31	$1.40	$1.47	$1.55	$1.61	$1.75	$1.87	$1.97
3,000cy[2]	.94	1.00	1.05	1.10	1.14	1.24	1.31	1.38
4,000cy	.82	.87	.91	.96	.99	1.07	1.14	1.19
5,000cy	.81	.86	.90	.95	.98	1.06	1.13	1.18
6,000cy	.80	.85	.90	.94	.98	1.06	1.12	1.18
7,000cy	.80	.85	.89	.93	.97	1.05	1.12	1.17
8,000cy	.80	.84	.89	.93	.97	1.05	1.11	1.17
9,000cy	.79	.84	.88	.92	.96	1.04	1.10	1.16
10,000cy	.79	.83	.88	.92	.96	1.04	1.10	1.16
15,000cy	.78	.83	.87	.91	.95	1.03	1.09	1.15
20,000cy	.77	.82	.87	.91	.94	1.03	1.09	1.14
25,000cy	.77	.82	.86	.91	.94	1.02	1.09	1.14
30,000cy	.77	.82	.86	.90	.94	1.02	1.09	1.14
35,000cy	.77	.82	.86	.90	.94	1.02	1.09	1.14

1. Includes loading, hauling and unloading costs, site maintenance and disposal costs; excludes site amortization and drop box depreciation.

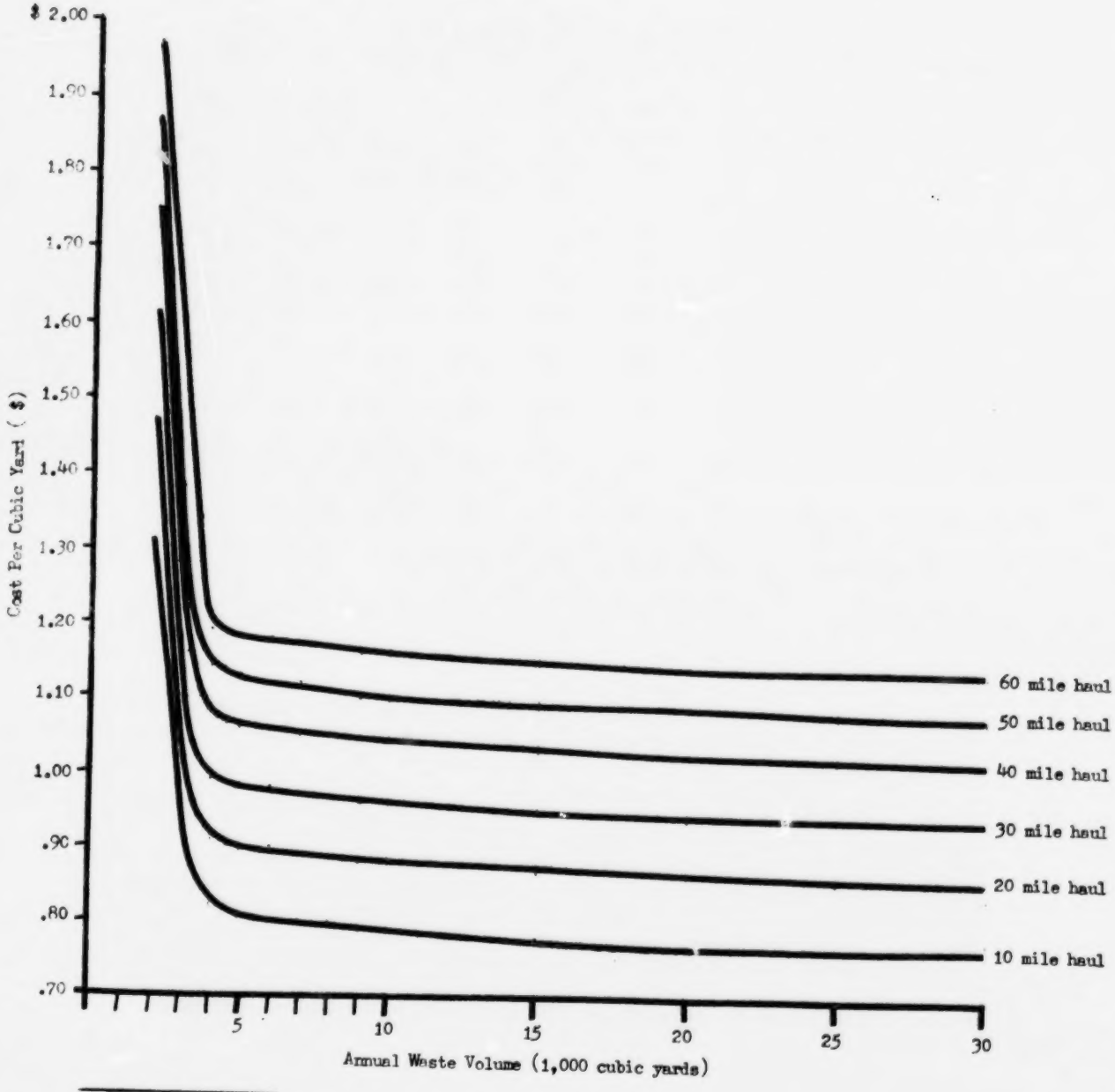
2. Estimates based on 52 trips per year to provide for weekly pick-up.

NOTE: It should be specifically noted that the data presented in Table 4 and Figure 6, while allowing for differences in haul distance and volume of waste, do not take into account variations in hourly costs of labor, equipment and overhead. They are based on the Lane County rates of $14.79 per hour (see page 7).

Source: Developed by adaptation of Lane County, Oregon experience, March-May 1973.

FIGURE 6

OPERATING COST PER YARD
BY VOLUME AND LENGTH OF HAUL
RURAL TRANSFER SYSTEM



Source: Table 4. See also qualifying notations on Table 4.

II. ESTIMATED COSTS, FISCAL YEAR 1974-75

FULL TRANSFER SYSTEM
Lane County, Oregon

Based upon data presented in Part I of this report and upon estimated volumes and assumed operating schedules outlined in the following paragraphs, operation of the Lane County transfer program could be expected to cost approximately $165,000 in fiscal year 1974-75. Adding depreciation of drop boxes and amortization of sites brings the total annual cost to $181,000.

Elements of cost common to all transfer stations in the county, outlined in some detail in the previous part of this report, are summarized below:

(1) Loading and unloading time: 80 minutes

(2) Hourly cost, equipment, labor, overhead: $14.79

(3) Volume hauled per trip: 67.5 cubic yards

(4) Disposal costs: $0.20 per cubic yard

(5) Contingency costs: 10% of total trip cost

(6) Site maintenance: $250 per site per year

(7) Transfer box annual depreciation: $857

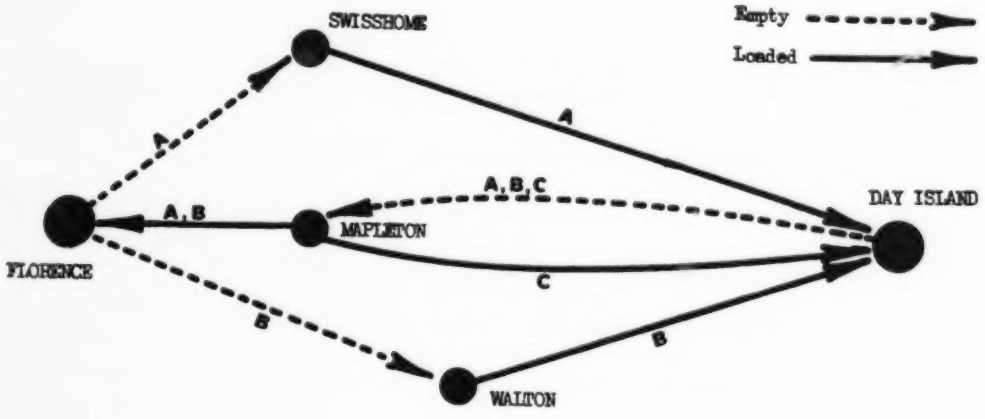
(8) Site development annual amortization: $500

In addition to these constants, the data presented in Table 5 were assumed for each transfer station site. Estimated costs for operating and maintaining each of the twelve stations in the system are shown in Table 6. These costs are reported on a per yard basis in Table 7.

As shown in Table 6, approximately 7,762 total man-hours would be required to operate the twelve-station system. Although year-round double-shift operation of two transfer vehicles could provide for over 8,000 man-hours per year, peak use periods, both seasonal and weekly, will necessitate the use of an additional tractor-trailer and complement of drop boxes to serve the Veneta and Rattlesnake stations during certain portions of the year. The cost of depreciating these additional drop boxes is included in the estimated costs.

The estimated cost data for the Walton, Mapleton and Swisshome stations is based on an assumption that the Walton and Swisshome sites would be served on a return trip from servicing the Mapleton station. Thus, the distances involved in transporting waste from both of these sites are

predicated on an origin of the vehicle from Florence and a destination at Day Island. The volumes expected at these stations (5,000 cubic yards annually each) would require 74 trips to each station. If the Walton and Swisshome stations were served on alternate trips to Mapleton (a total of 148 trips), 89 trips to Mapleton with no need to haul from either Walton or Swisshome would be made. On these 89 trips, it is assumed that the Mapleton material would be transported back to Day Island rather than to Florence. This assumed series of trips is illustrated in the chart below.



The Five Rivers station is expected to receive about 2,000 cubic yards of material per year. Although this volume could be transferred in about 30 trips, the cost data presented in Tables 6 and 7 assume that at least one pick-up per week will be necessary.

Table 5

DISTANCE TO REGIONAL LANDFILL AND ESTIMATED 1974 WASTE VOLUMES
Twelve Lane County, Oregon Transfer Stations

Transfer Station	Regional Landfill Serving Station	Distance Landfill to Station (miles)	Average Haul Speed[1]	Annual Waste Volume Reported 1971	Annual Waste Volume Estimated 1974
Veneta	Day Island	18	27MPH	32,637cy	40,000cy
Rattlesnake	Day Island	16	25	20,860	35,000
McKenzie Bridge	Day Island	54	45	9,723	14,500
Mohawk	Day Island	20	29	12,597	18,000
Vida-Leaburg	Day Island	24	32	8,189	16,000
Walton	Florence[2] Day Island[2]	29 45	34 41	3,799	5,000
Sharps Creek	Cottage Grove	15	25	4,268	8,000
Mapleton	Florence[2] Day Island[2]	21 53	30 44	9,326	16,000
London	Cottage Grove	15.6	25	3,959	7,500
Horton	Day Island	45	41	6,902	10,000
Swisshome	Florence[2] Day Island[2]	34 66[a]	36 49	2,749	5,000
Five Rivers	Florence	50	43	1,464	2,000
TOTAL				116,473cy	177,000cy

1. See Table 2 and Figure 3, Part I of this report.

2. Scheduling of Walton and Swisshome stations contemplated alternately on Mapleton trips. When neither Walton nor Swisshome haul is contemplated, Mapleton trip originate and destine at Day Island, see Figure and text, page 16.

a. Shorter routes are available, but not useable by transfer tractor and trailer (oversize equipment).

Table 6

ESTIMATED ANNUAL COSTS
LANE COUNTY SOLID WASTE TRANSFER SYSTEM
Fiscal Year 1974-75

Transfer Station	Total Trip Time (hours)	Number of Trips	Total Hours	Cost Per Trip	Annual Cost All Trips	Other Operating Costs	Disposal Costs	Total Annual Operating Cost	Depreciation and Amortization	Total Annual Cost
Veneta	2.67	593	1,583.3	$39.49	$ 23,418	$ 2,592	$ 8,000	$ 34,009	$ 1,357	$ 35,366
Rattlesnake	2.61	519	1,354.6	38.60	20,033	2,253	7,000	29,287	1,357	30,644
McKenzie Bridge	3.73	215	802.0	55.17	11,862	1,436	2,900	16,198	1,357	17,555
Mohawk	2.71	267	723.6	40.08	10,701	1,320	3,600	14,363	1,357	16,979
Vida-Leaburg	2.83	237	670.7	41.86	9,921	1,242	3,200	14,363	1,357	15,720
Walton	3.28	74	242.7	48.51	3,590	609	1,000	5,199	1,357	6,556
Sharps Creek	2.53	119	301.1	37.42	4,453	695	1,600	6,748	1,357	8,015
Mapleton (Day Island to Florence)	3.23	148	478.0	47.77	7,070	1,449	3,200	16,642	1,357	17,999
Mapleton (Day Island to Day Island)	3.74	89	332.9	55.31	4,923					
London	2.58	112	289.0	38.16	4,274	677	1,500	6,451	1,357	7,808
Horton	3.53	149	526.0	52.21	7,779	1,028	2,000	10,807	1,357	12,164
Swisshome	3.62	74	267.9	53.54	3,962	646	1,000	5,608	1,357	6,965
Five Rivers	3.66	52	190.3	54.13	2,815	531	400	3,746	1,357	5,103
TOTALS:										
RURAL LANE COUNTY		2,626	7,762.0		$114,800	$14,480	$35,400	$164,680	$16,284	$180,964
RURAL LANE COUNTY LESS FIVE RIVERS SITE[a]		2,574	7,571.7		$111,985	$13,949	$35,000	$160,934	$14,927	$175,861

a. Five Rivers is a small remote site, currently being operated under contract to a resident in the area. Because of its size and its geographic isolation from the rest of the county, it is not likely that the site can be considered feasible for a transfer operation. Instead, the site will continue to be operated in some manner as a modified landfill.

Table 7

TRANSFER SYSTEM COST PER CUBIC YARD
LANE COUNTY TRANSFER STATIONS
Fiscal Year 1974-75

Transfer Station	Cost Per Cubic Yard	
	Annual Operating	Annual Total
Veneta	$0.850	$0.884
Rattlesnake	0.836	0.875
McKenzie Bridge	1.117	1.210
Mohawk	0.867	0.943
Vida-Leaburg	0.897	0.982
Walton	1.039	1.311
Sharps Creek	0.843	1.001
Mapleton	1.040	1.124
London	0.860	1.041
Horton	1.080	1.216
Swisshome	1.121	1.393
Five Rivers	1.873	2.551
AVERAGE, LANE COUNTY	$0.930	$1.022

III. RURAL LANDFILL OPERATIONS

LANE COUNTY

The Lane County solid waste system has included providing unattended rural landfill sites, periodically worked by roving crews. The operation of the County's twelve rural landfills during a 12-month period from August 1971 through July 1972 required 7,272 man-hours of labor and 4,505 hours of equipment use. Materials and supplies costs amounted to $2,832 for the same period of time. Of the man-hours recorded during the 12-month period, 87 per cent was for work at the sites. The other 13 per cent represents travel (transit) time.

The amounts of labor and equipment used to operate these 12 landfill sites varies considerably from site to site in both absolute and relative terms. Excluding pickup truck use and time spent in transit to and from the job site, a systemwide average of 24.4 machine-hours and 54.2 man-hours per 1000 cubic yards of waste handled was reported for the 12-month period, although significant variations from that average are apparent (Table 8).

Table 8

EQUIPMENT AND LABOR INPUTS
By Landfill Site
Lane County, Oregon
August 1971 to July 1972

Site	1971 Volume (cy)	Equipment Hours				Man-Hours			
		Total		On Site[a]		Total		On Site[ab]	
		Number	Per 1000 cy	Number	Per 1000 cy	Number	Per 1000 cy	Number	Per 1000 cy
Veneta	32,637	1,300.0	39.8	1,011.0	31.0	1,686.0	51.7	1,490.0	45.7
Rattlesnake	20,860	887.4	42.5	583.0	27.9	1,187.5	56.9	1,005.0	48.2
Mohawk	12,597	393.6	31.2	241.5	19.2	456.5	36.2	377.0	29.9
McKenzie Br.	9,723	247.1	25.4	110.5	11.4	1,494.0	153.7	1,392.0	143.2
Mapleton	9,326	311.1	33.4	214.5	23.0	324.0	34.7	262.0	28.1
Vida-Leaburg	8,189	214.6	26.2	93.5	11.4	350.5	42.8	294.5	36.0
Erbs	5,155	223.3	43.3	88.0	17.1	330.5	64.1	257.0	49.9
Disston	4,263	192.7	45.2	90.5	21.2	305.0	71.5	250.0	58.6
London	3,959	237.0	59.9	101.5	25.6	377.5	95.4	287.0	72.5
Walton	3,799	243.6	64.1	147.5	38.8	374.5	98.6	309.5	81.5
Swisshome	2,749	185.0	67.3	97.5	35.5	269.5	98.0	213.5	77.7
Horton	1,747	69.2	39.6	28.0	16.0	116.5	66.7	98.5	56.4
TOTAL	115,004	4,504.6	39.2	2,807.0	24.4	7,272.0	63.2	6,236.0	54.2

a. Excludes time in transit to and from landfill site and pickup truck time.

b. Excludes time in transit to and from landfill site.

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Of particular significance is an indication that sites receiving up to approximately 10,000 cubic yards of loose waste per year require equal amounts of site operating time. Note from Table 8 that approximately equal equipment and labor hours are required for all sites receiving less than 10,000 cubic yards. The major exceptions are due to special operation variations. The reason that volume of waste is not a factor in the cost of operating such sites is that a basic amount of work must be performed on each trip on a regular schedule if each modified landfill is to meet common standards. The amount of work required is indicated by a review of the six most typical Lane County low volume landfills. These sites received between 3,800 and 9,300 cubic yards of waste.

Average Time Per Site at Low Volume Sites

Hours	Per Year	Per Week
Total Equipment Hours	233	4.50
On Site Equipment Hours	123	2.40
Crawler Equipment Hours	65	1.25
Total Man Hours	344	6.60
On Site Man Hours	290	5.60

Also significant is an indication that higher volume rural landfills will not necessarily result in lower unit costs. If the data for the three larger sites is compared with that for the average of the low volume sites, the amount of time is found to be markedly greater for Lane County's heavier volume rural sites. The increase is particularly noticeable for on site work.

Comparative Time: Low Volume and Larger Sites

Sites	Volume	Equipment Hours		Man Hours	
		Total	On Site	Total	On Site
Low Volume	3,800 - 9,300	233	123	344	290
Mohawk	12,600	394	242	457	377
Rattlesnake	21,000	887	583	1,188	1,005
Veneta	33,000	1,300	1,011	1,686	1,490

The reason that the equipment and personnel time increase for heavier volume sites is at a greater rate than the volumes increase is due to various factors. The primary reason is probably that good sites are harder to find in the locations where larger volumes of waste are generated, and at the same time, the greater number of residents in the area make careful operation

more essential. For example, twice weekly covering is practiced at the Veneta site during portions of the year. Also, because of the waste volumes, there is greater concern for special operations problems such as leachate control.

To estimate modified landfill costs, some appreciation for the various activities that may be necessary is helpful. Although a major portion of time devoted to Lane County's rural landfills is spent in general operation and maintenance of the landfill sites, a number of other functions related to the operation of the system were reported (Table 9).

Table 9

LABOR, EQUIPMENT AND MATERIALS INPUTS BY FUNCTION
Lane County Rural Landfills
August 1971 through July 1972

Functions	Number of Sites Reporting	Man-Hours	Equipment Hours	Materials Costs
Landfill operations, general	12	5,783.5	3,214 0	$ 81
In-transit to job site	12	1,032.0	936.4	--
Rock and gravel haul	7	167.0	163.0	1,868
Spraying	7	65.0	41.0	32
Maintenance blading	5	47.0	64.0	--
Surveying, prelim. location	1	36.0	1.2	--
Sign installation	8	32.0	16.0	191
Roadway preparation	1	23.0	23.0	--
Ditch & channel excavation	1	18.0	9.2	--
Standby time	3	15.0	10.0	--
Electrical equipment, installation, maintenance	1	14.0	1.2	--
Clearing and grubbing	1	8.0	5.2	--
Roadway excavation	1	8.0	8.0	--
Asphalt storage plant operations	1	8.0	1.2	--
Roadside litter removal	1	5.0	2.8	--
Field maint. to equipment	1	4.0	4.0	--
Roadside mowing	1	3.5	1.2	--
Excavation of solid rock	1	2.0	2.0	--
Culvert laying	1	--	--	123
Private work by outside forces	3	--	--	35
Miscellaneous activities, Solid Waste Division	1	1.0	1.2	501
TOTAL, ALL FUNCTIONS	12	7,272.0	4,504.6	$2,832

The function "rock and gravel haul" accounts for activities connected with transportation of both cover material and material for road maintenance and reconstruction of the dumping area. Similarly, roadway preparation, roadway excavation and maintenance blading are mostly accounted for by maintenance of the access road and dumping area, but some work on trench walls and bank faces is also included in these functions. Swarms of yellow-jackets, particularly during late summer and early fall, constitute a problem at a number of the sites, and efforts to repel them by spraying required considerable time. The conduct of preliminary location surveys at the Veneta site involved staking a new trench as well as re-staking the landfill property lines. Other functions reported in Table 9 are sufficiently descriptive of activities performed. Although not presented in Table 9, data from the 1972-73 fiscal year records indicate that the following functions also need to be accounted for over a period of time:

- cutting and burning roadside vegetation
- project and maintenance cleanup
- slide control
- cleaning and restoring culverts
- removing snow
- location design
- construction engineering
- vandalism to signs

It will be noted also that administrative activities (clerical, supervision and management) are not included in the activities reported in Table 9. These functions are covered by an overhead charge applied against salaries and wages of operations personnel.

Labor

The Solid Waste Division employed 40 persons in its workforce at various times throughout the 12-month period, distributed among six broad worker classifications as follows:

Administrative workers	5
Foremen or supervisors	2
Equipment operators	14
Site attendants	8
Laborers	5
Temporary laborers (summer)	6

Twenty-four of these employes charged time direct to a rural landfill site at least once during the 12 months included in the analysis, and three employes reported time spent in rural landfill operations in every one of those months. On the average, 12 employes charged time against the landfill sites in any one month. On balance, greater amounts of time were spent at the rural landfills during the summer months than at other times of the year, but variations from this general pattern also are evident in a few individual sites (Tables 10 and 11.)

Table 10

NUMBER OF WORKERS AND MAN-HOURS WORKED
Lane County Rural Landfills
1971-1972

Month	Number Man-Hours Worked	Number of Workers[1]				
		All Types	Foremen	Equipment Operators	Site Attendants	Laborers[2]
Average Month	606.0	12	--	9	2	1
August[3]	720.5	17	1	12	2	2
September	929.0	14	--	10	2	2
October	467.0	9	--	6	2	1
November	594.0	13	--	9	2	2
December	706.5	11	--	8	2	1
January	534.0	12	--	9	2	1
February	415.0	10	--	7	2	1
March	517.5	12	--	9	2	1
April	395.0	9	--	8	1	--
May	454.5	12	--	10	2	--
June	806.5	13	--	9	1	3
July	732.5	14	--	9	1	4

1. Number of workers includes solid waste division employes only. This workforce is augmented by crews from the road and bridge and engineering divisions on construction and related activities. The man-hours worked by all employes, including road and bridge and engineering crews, is represented in this data.
2. Includes temporary labor during the summer months.
3. Hours reported for August may be low because of possibly incomplete data on three sites.

Table 11

LABOR INPUTS: AVERAGE, HIGH AND LOW MONTHS
Lane County Rural Landfills
August 1971 to July 1972

Site	Average Monthly Man-hours	High Month		Low Month	
		Month	Man-Hours	Month	Man-hours
Veneta	140.5	Sept.	409.5	October	41.5
Rattlesnake	99.0	August	151.0	January	59.0
Mohawk	38.0	June	86.0	Oct./Nov.	24.0
McKenzie Bridge	124.5	January	217.0	April	41.0
Mapleton	27.0	August	48.5	October	6.0
Vida-Leaburg	29.2	June	43.5	April	18.0
Erbs	27.5	December	49.0	November	10.0
Disston	25.4	March	72.0	February	12.0
London	31.5	November	78.0	Oct./Jan.	14.0
Walton	31.2	July	64.0	February	9.0
Swisshome	22.5	June	43.5	January	11.0
Horton	9.7	January	23.0	February	4.0
TOTAL	606.0	September	929.0	April	395.0

Equipment

A total of 17 major types of equipment were used in rural landfill operations during the 12 months included in this analysis. These classifications are listed in Table 12.

Table 12

EQUIPMENT USED, BY TYPE OF EQUIPMENT
Lane County Rural Landfills
August 1971 - July 1972

Type of Equipment	Number of Pieces	Total Hours
Crawler tractors	6	1,560.0
Scrapers, self-loading	2	19.5
Scrapers, other	3	145.0
Motor graders	6	90.0
Shovels, backhoes	2	29.0
Front-end loaders	4	56.0
Rollers, compactors	5	63.0
Transport tractor-trailers	6	750.4
Pickup trucks	31	947.2
Dump trucks, 5-6 yards	8	46.0
Dump trucks, 8-10 yards	13	196.5
Off-road, 12-yard rock dumps	2	4.5
Fire trucks	2	534.5
Flat-bed truck	1	4.0
Sign service truck	1	19.5
Water trucks	2	14.5
Pull-tank trailers	2	25.0
TOTAL, ALL TYPES	96	4,504.6

As shown in Table 13,crawler tractors, front-end loaders, dump trucks and fire trucks were used at virtually every site in the system, in addition to the pickup trucks and the transport tractor-trailer rigs. Additional pieces were used at various sites, depending upon the work undertaken at those locations during the year. As might be expected, the Veneta site (the largest in the system) utilized the widest variety of equipment, but with that exception, there is no particularly evident relationship between site size and the variety of equipment used. With the exception of the graders, dump trucks, the flat-bed and sign service trucks and the pull-tank (and, of course, the transport tractor-trailers), the equipment was

used primarily for general operations of the several landfills. The crawlers were used primarily for moving the waste material and for compacting and covering it. Scrapers and shovels were used for trench construction, the non-self-loading scrapers being used in combination with a crawler. Motor graders were used primarily for construction and maintenance of the access roads and dumping areas, although at times they were used for trench construction. The loaders were involved principally in moving cover material and in digging trenches. The dump trucks, including the 12-yard off-road rock dumps, were used for moving cover and roadway material. The water truck was used in construction activities and the pull-tank trailers were used in the spraying operations. Fire trucks and sign service truck were used exclusively for their designed purposes. (The fire truck time is for county equipment and does not include time of cooperating fire fighting agencies.) The flat bed served as a utility vehicle in the clearing operations at the Veneta site (Table 14).

Hours of use of pickup trucks and transport vehicles follows a pattern similar to other equipment. However, this equipment is affected by the distance between the shops and the various sites as well as by site activity.

	Equipment Hours		
	Total On-Site	Transfer Vehicles	Pickups
Low volume sites	123	37	68
Mohawk	242	59	94
Rattlesnake	583	164	140
Veneta	1,011	127	162

Decisions as to which portion of a route servicing several landfills to charge to each landfill affect the amount of transfer vehicle and pickup time allocated to each disposal site.

For the most part, the equipment was not purchased by the county specifically for landfill work, and with a continuing solid waste management program involving rural landfills, new equipment having increased flexibility for landfill operations would be acquired. On the other hand, the lack of specially designed equipment is not considered as having a major impact on the cost of the program. One savings could be a reduction in pickup truck use if the crawlers used were narrow enough to permit over-the-road transport without a lead vehicle. (See Tables 13 and 14.)

Table 13

HOURS OF EQUIPMENT USE BY SITE AND BY TYPE OF EQUIPMENT
Lane County Rural Landfills
August 1971 - July 1972

Equipment Type	Hours of Use by Site											
	Veneta	Rattle-snake	Mohawk	McKenzie Bridge	Mapleton	Vida	Erbs	Disston	London	Walton	Swiss-home	Horton
Crawler tractors	596.5	330.0	83.0	69.0	89.5	50.0	60.5	45.5	64.5	82.5	61.0	28.0
Self-loading scrapers	7.0	--	3.0	--	4.5	--	--	--	--	5.0	--	--
Other scrapers	145.0	--	--	--	--	--	--	--	--	--	--	--
Motor graders	31.0	--	6.0	21.0	--	7.0	8.0	--	--	--	17.0	--
Shovels, backhoes	7.0	--	--	--	--	--	--	--	22.0	--	--	--
Front-end loaders	15.0	13.0	5.0	2.0	--	--	--	8.0	5.0	3.0	5.0	--
Rollers, compactors	36.0	15.0	6.0	--	3.0	2.0	--	--	1.0	--	--	--
Dump trucks, 5-6 yard	27.0	3.0	2.0	3.0	--	4.0	4.0	--	--	--	3.0	--
Dump trucks, 8-10 yard	117.0	17.0	10.0	--	--	12.0	13.5	22.0	--	5.0	--	--
Off-road rock dump trucks	2.0	--	2.5	--	--	--	--	--	--	--	--	--
Fire trucks	13.0	201.0	110.0	12.0	114.0	12.5	--	15.0	6.0	41.5	9.5	--
Flat bed trucks	4.0	--	--	--	--	--	--	--	--	--	--	--
Sign service trucks	2.5	2.0	3.0	3.5	2.0	1.5	--	--	--	3.0	2.0	--
Water trucks	2.0	--	7.0	--	--	2.5	--	--	3.0	--	--	--
Pull-tank trailer	6.0	2.0	4.0	--	1.5	2.0	2.0	--	--	7.5	--	--
Transport tractors, trailers	127.0	164.0	58.5	77.0	39.0	44.9	49.5	42.0	61.5	42.5	35.5	9.0
Pickup trucks	162.0	140.4	93.6	59.6	57.6	76.2	85.8	60.2	74.0	53.6	52.0	32.2
TOTAL	1300.0	887.4	393.6	247.1	311.1	214.6	223.3	192.7	237.0	243.6	185.0	69.2

Table 14

EQUIPMENT USED, BY FUNCTION
Lane County Rural Landfills
August 1971 - July 1972

Function	Hours of Use							
		Scrapers						
	Crawler Tractors	Self Load	Other	Motor Graders	Shovel, Backhoe	Front End Loaders	Rollers, Compact.	Transport Tractor-Trailer Rigs
Landfill operations, gen.	1,541.0	14.5	133.0	10.0	26.0	52.0	41.0	14.0
In transit to job site	7.0	5.0	8.0	--	3.0	--	8.0	736.4
Rock and gravel haul	--	--	--	--	--	4.0	--	--
Spraying	--	--	--	--	--	--	4.0[a]	--
Maintenance blading	--	--	--	51.0	--	--	--	--
Prelim. location survey	--	--	--	--	--	--	--	--
Sign installation	--	--	--	--	--	--	--	--
Roadway preparation	--	--	--	13.0	--	--	10.0	--
Ditch, channel excavation	--	--	--	8.0	--	--	--	--
Standby time	10.0	--	--	--	--	--	--	--
Electrical equipment installation, repair	--	--	--	--	--	--	--	--
Clearing, grubbing	--	--	--	--	--	--	--	--
Roadway excavation	--	--	--	8.0	--	--	--	--
Asphalt storage plant	--	--	--	--	--	--	--	--
Roadside litter removal	--	--	--	--	--	--	--	--
Field maint. to equipment	--	--	4.0	--	--	--	--	--
Roadside mowing	--	--	--	--	--	--	--	--
Excavation of solid rock	2.0	--	--	--	--	--	--	--
Miscellaneous activities	--	--	--	--	--	--	--	--
TOTALS	1,560.0	19.5	145.0	90.0	29.0	56.0	63.0	750.4

Function	Trucks			Special Equipment Trucks					
		Dump		Rock		Flat	Sign		Pull-tank
	Pickup	5-6 yd.	8-10 yd.	10-12 yd.	Fire	Bed	Service	Water	Trailer
Landfill operations, gen.	770.0	18.0	45.0	4.5	530.5	--	--	14.5	--
In transit to job site	141.0	--	19.0	--	9.0	--	5.0	--	--
Rock and gravel haul	--	28.0	131.0	--	--	--	--	--	--
Spraying	12.0	--	--	--	--	--	--	--	25.0
Maintenance blading	13.0	--	--	--	--	--	--	--	--
Prelim. location survey	1.2	--	--	--	--	--	--	--	--
Sign installation	--	--	1.5	--	--	--	14.5	--	--
Roadway preparation	--	--	--	--	--	--	--	--	--
Ditch, channel excavation	1.2	--	--	--	--	--	--	--	--
Standby time	--	--	--	--	--	--	--	--	--
Electrical equipment, installation, repair	1.2	--	--	--	--	--	--	--	--
Clearing, grubbing	1.2	--	--	--	--	4.0	--	--	--
Roadway excavation	--	--	--	--	--	--	--	--	--
Asphalt storage plant	1.2	--	--	--	--	--	--	--	--
Roadside litter removal	2.8	--	--	--	--	--	--	--	--
Field maint. to equipment	--	--	--	--	--	--	--	--	--
Roadside mowing	1.2	--	--	--	--	--	--	--	--
Excavation of solid rock	--	--	--	--	--	--	--	--	--
Miscellaneous activities	1.2	--	--	--	--	--	--	--	--
TOTALS	947.2	46.0	196.5	4.5	534.5	4.0	19.5	14.5	25.0

Materials and Supplies

A significant proportion of the materials and supplies purchased for the county's rural landfill operations during the 12 months included in this analysis could be classified as capital outlays.

As shown in Table 15, the purchase of crushed rock (used mostly in road and dumping area maintenance and reconstruction) and fire hose and fittings (to meet then current DEQ requirements) accounted for nearly 85 per cent of the total dollars spent on materials and supplies for these rural sites.

Table 15

MATERIALS AND SUPPLIES PURCHASED
Lane County Rural Landfills
August 1971 - July 1972

Item	Amount
Sand, Gravel, Rock	
Bar run gravel	$ 18.00
3/8 reject crushed rock	63.40
3/4 crushed rock	991.85
1 1/2 crushed rock	896.96
Culvert Pipe, 8" metal	21.60
Signs, Signposts	
Guide signs	171.70
Special signs	12.50
Sign posts	19.50
Employe Expenses (meals, lodging)	29.40
Fire Hose and Fittings	500.81
Miscellaneous	
Service charges (utilities)	5.50
Spray supplies	31.87
Miscellaneous maintenance supplies	10.40
Miscellaneous special services	58.80
TOTAL, ALL SUPPLIES PURCHASED	$2,832.29

Landfill Operations: Some Generalizations

A basic factor in the operation and maintenance of rural landfill is the time spent by crawler tractors in moving, compacting and covering waste material.

In Lane County, total crawler tractor time in general landfill operations amounted to 1,560 hours during the 12 months encompassed by the analysis. After making adjustments to these data to account for the use of tractors as push cats for non-self-loading scrapers, the tractor time represented 51 per cent of the annual equipment hours for on-site work.

Annual crawler tractor hours in waste handling and cover operations:	1,408
Annual equipment hours on site:	2,764*

* Does not include pickup truck time or transport vehicle time.

The on-site equipment hours for modified landfills receiving less than 10,000 cubic yards annually averaged 2.4 hours per week per site. Crawler tractor equipment represented 1.25 hours per week per site. Recognizing that the Lane County program has not met all standards for once a week compaction and cover of all waste, and after discussing operation experience with the Lane County Solid Waste Division personnel, it is estimated that a scheduled weekly working of rural landfill sites using the equivalent of a D-7 Cat would require a minimum of two hours per site each week, and that this time would increase to three hours per week for sites receiving 10,000 cubic yards per year. For sites receiving over 10,000 cubic yards of loose waste per year, 1.7 hours in excess of the two hour base should be added to the tractor time for each additional 5,000 cubic yards of waste per year. These estimates allow time for loading and unloading equipment, equipment cleanup and other tasks necessary under a roving crew system.

For each hour of crawler tractor time devoted to waste handling and covering, an hour of other equipment time also should be allocated. Use of this additional equipment will not take place in a regular weekly routine, but instead will be related to various tasks (trench digging, road maintenance, fire control, etc.). In some instances a tractor could be used for some of these operations, although in many instances different equipment will be required because of the nature of the work.[1]

1. It may be appropriate to note also that the type of equipment used at various rural landfill sites probably will be influenced to a certain extent by the type of equipment conveniently available for use at those sites. Conversely, it is not likely that special equipment will be purchased for rural landfill operations in most of the smaller counties, and to the extent that those pieces are not available, the crawler tractor will be more extensively used even though another piece might be technically more "efficient" for that particular task.

Under these conditions, equipment hours by size of operation will approximate those shown in Table 16.

Table 16

ON-SITE EQUIPMENT AND MAN HOURS BY SITE SIZE

Size of Operation Cubic Yards Per Year	Landfill Crawler Tractor Weekly Hours	Landfill Crawler Tractor Annual Hours	Total Annual Equipment Hours	Annual Man Hours
Under 10,000 cy	2.0	104	208	416
10,000	3.0	156	312	624
15,000	3.7	192	384	725
20,000	5.4	281	562	974
25,000	7.1	369	738	1,220
30,000	8.8	458	916	1,469
35,000	10.5	546	1,092	1,716
40,000	12.2	634	1,268	2,001

On-site labor time in man hours in the Lane County system averaged 2.26 times that of machine time for six low volume sites and averaged 1.56 times machine time for the heavier volume sites. If operation of the low volume sites is improved to a minimum of two hours of waste handling and cover work per week per site, the increased amount of equipment time required would reduce the ratio of man hours to equipment hours, but the ratio is not likely to go below two man hours for each machine hour on site. Based on the estimate of 208 equipment hours per year for low volume sites, man hours would then equal 416 per year per site. At higher volume sites, the man hours are estimated to increase to 624 when the volume reaches 10,000 cubic yards per year and an additional 1.4 hours for each equipment hour in excess of 312. The estimated labor requirements then would be about as given in Table 16.

The estimating technique outlined above should roughly account for most contingencies as well as for time involved in other recurring activities associated with landfill operation and maintenance (including road work, insect control, sign installation, etc.). It would not include transit time for equipment or labor, a factor which would be a function of distance.

The conversion of these estimated labor and equipment requirements to dollars is basically a matter of factoring the estimated man and equipment

hours by an established rate. This factor will of course vary from area to area depending upon wage rates and the kind of equipment used at various sites. The locally established method for recovering expenses of gas, oil and maintenance, as well as for establishing a depreciation reserve, will affect the method of calculating these costs but should not materially alter the resulting estimate.

A worksheet for preparing gross estimates of landfill costs is included on page 34 (Figure 7). Considerations involved in calculating these several cost items are outlined in the remaining paragraphs of this report.

Equipment Costs

In Lane County, all equipment utilized in the solid waste management program is rented from the county motor pool. The rates charged for equipment use are sufficient to cover all costs associated with equipment ownership and operation including gas, oil, maintenance, insurance and depreciation (replacement). The basic rate for a crawler tractor (D-7 Cat or equivalent) is $7.20 per hour.[1] Hourly charges for other pieces of equipment commonly used on the landfill sites are as follows:

Self-loading scrapers	$11.50	5-6 yd dump trucks	$3.00
Other scrapers	8.00	8-10 yd dump trucks	5.45
Motor graders	8.75	10-12 yd rock dumps	8.00
Shovels, backhoes	8.45	Fire trucks	5.45
Front-end loaders	5.15	Flat bed truck	1.35
Compactors	11.50	Sign service truck	3.00
Transport tractors-trailers	8.30	Water truck	5.45
		Pull tank trailer	.65

In estimating the cost of these other pieces of equipment, the fact that the hourly rates vary considerably as well as the fact that not all pieces are used to even a similar extent must be taken into account. An analysis of the Lane County experience, however, indicates that aggregate on-site equipment use (other than crawler tractors, pickups and fire trucks) averaged about $6.00 per hour for the six low volume sites and between $6.50 and $7.00 for the three higher volume sites.

Site	Annual Volume (cy)	Average Misc. Equipment Cost Per Hour*
Six low volume sites	Under 10,000 cy	$5.96
Mohawk	12,597	6.51
Rattlesnake	20,860	6.83
Veneta	32,637	6.81

* Excluding crawler tractors, fire trucks, pickup trucks and equipment in transit.

1. Actual operating time or "time on the engine."

FIGURE 7

LANDFILL SITE ANALYSIS WORKSHEET

(a) Annual volume of loose waste _____cy

(b) Landfill crawler tractor annual hours* _____hours

(c) Landfill crawler tractor hourly rate $_____

(d) Landfill crawler tractor annual cost [b x c] $_____

(e) Other equipment annually on site* _____hours

(f) Weighted average rate, misc. equipment $_____

(g) Other equipment annual cost [e x f] $_____

(h) Fire trucks annual cost [$50 x (a ÷ 1,000)] $_____

(i) Distance of site from equipment base _____miles

(j) Average haul speed (from Figure 3) _____MPH

(k) Time in transit per trip [2i ÷ j] _____hours

(m) Transport of equipment hourly rate $_____

(n) Transport cost per trip [k x m] $_____

(p) Pickup truck rate per mile $_____

(q) Pickup truck cost per trip [2i x p] $_____

(r) Trips per year (minimum 52) _____

(s) Total annual transport cost [(n + q) x r] $_____

(t) Transportation of other equipment to site $_____

(u) TOTAL ANNUAL EQUIPMENT COST [d + g + h + s + t] $_____

(v) Equipment operation time [b + e] _____hours

(w) Equipment operator hourly rate $_____

(y) Equipment operator annual cost [v x w] $_____

(z) Utility man annual hours [man hours Table 16 - v] _____hours

(aa) Utility man hourly rate $_____

(bb) Utility man annual labor cost [z x aa] $_____

(cc) Transit time cost, equipment operator [r x k x w] $_____

(dd) Transit time cost, utility man [r x k x aa] $_____

(ee) Total direct annual labor cost [y + bb + cc + dd] $_____

(ff) Overhead [ee x rate (_____%)] $_____

(gg) TOTAL ANNUAL LABOR COSTS [ee + ff] $_____

(hh) Contingency $_____

(ii) TOTAL LANDFILL OPERATING COST [u + gg + hh] $_____

(jj) Site improvement, annual depreciation $_____

(kk) Annual site value depreciation**(+) or appreciation(-) $_____

(mm) TOTAL SITE AMORTIZATION COST [jj + kk] $_____

TOTAL ANNUAL LANDFILL COSTS [ii + mm] $_____

* See Table 16.

** Or annual lease payment (+) for use of site.

Fire trucks from the county motor pool (at $5.45 per hour) were used for only 61 hours at the six low volume sites, and logged only 13 hours at the Veneta site, the county's largest. Aside from the unpredictability of their use at any given site at any given time, the low level of fire truck use at Veneta and the six smaller sites was due to the fact that fire suppression at these sites was handled to a greater extent by local fire departments and rural fire protection districts. The time spent by these agencies at landfill fires is not known. In the absence of such external assistance, however, some allowance should be made for the cost of fire trucks serving the rural landfill sites. Annual fire truck use at the Mohawk and Rattlesnake sites in Lane County amounted to about 8.75 and 8.5 hours per 1,000 cubic yards of loose waste, respectively. This very limited information suggests that for estimating purposes, a cost of about $50 per 1,000 cubic yards should be sufficient to completely cover special equipment use in fire suppression activities, assuming that the $5.45 per hour rate is reasonably reflective of fire truck costs.

The transportation of equipment from site to site involves at least two basic units; (1) the transport tractor-trailer rig and (2) a pickup truck. The tractor-trailer (most generally a lowboy) is used to move working equipment from site to site; and is usually driven by the equipment operator. The pickup serves two purposes: as a flag vehicle for oversized loads and as a means of transporting the roving crew to and from the job sites when the transport vehicle is left in the field overnight. If the equipment used to work the site is not so large as to constitute an oversized load, and if the scheduling of roving crew work is such that the equipment can be returned to the home base each night,[1] both the equipment operator and the site maintenance man could ride in the transport tractor, eliminating the need for a pickup truck.

As proposed in the worksheet (Figure 7), one transit equipment trip and one pickup trip occur for each weekly compaction and cover operation. No additional in-transit time is estimated. Equipment such as trucks will have transit time as well as site operation time. It appears that the available equipment time data did not separate the transit time and the site operation time for most self-transported vehicles. No attempt has been made to adjust the data in this regard. This may have the effect of slightly underestimating costs for distant sites and overestimating costs for close-in sites.

Additional transit equipment trips are likely to occur, related to the use of other equipment that is not self-transportable. Similarly, additional pickup trips are likely to occur, related to both additional transit equipment trips and to other personnel trips from the county shops to landfill sites. These added trips are increasingly probable in the case of larger volume sites since larger volume sites may need

1. In a few cases, it might be economical to arrange for roving crews to spend the night in a community closer to the job site, if appropriate facilities are available in the area and if labor contracts or agreements would permit such an arrangement on a routine basis.

to be worked more often than once a week in order to maintain an acceptable standard of quality, to avoid overfilling the dumping area or to minimize fire risks. The equipment and labor estimates in Table 16 for on-site work will permit more frequent compaction and cover activities, if this is the preferable operation method. Transit time adjustments will need to be made in this regard after considering the specific situation that is being analyzed. Nominal additions in transit trips and pickup use can be recognized somewhat in the selection of a contingency cost figure if refinement of the analysis technique to estimate the number and cost of additional trips does not appear justified.

Generally, the time involved in the transportation of equipment to and from the rural landfill sites is a function of distance. Estimates of time requirements should be made on the same basis as for transfer operations (see Figure 3, page 8).

Labor Costs

For each hour of equipment time logged on the site, an hour of equipment operator time will be required. In addition, at the lower volume sites, at least one other man hour per equipment hour will be spent, most frequently by a utility-maintenance worker who helps with cleanup and general site maintenance work. At the larger sites a somewhat less intensive labor input could be expected (see Table 16 and accompanying text). An additional hour of operator time and utility-maintenance worker time will be required for each hour of transit time. Transit time generally will equal the hours logged by the transport tractor-trailer, although adjustments should be made if the slower moving transport rig is left in the field overnight and the crew utilizes the pickup truck for transportation from that location to the home base and back again the following morning.

Overhead charges to cover administrative and similar nonallocable time costs plus any payroll expense items should be added to the direct labor cost at a percentage rate that will adequately account for those indirect costs. This overhead cost could be included either as a part of the hourly labor rate structure or as a separately computed item, depending upon local accounting practices.

Site Improvements Depreciation

The technique developed for estimating operations costs accounts for trench construction and for periodic maintenance and reconstruction of access roads, dumping areas and ordinary drainage systems. These activities would be handled by the roving crew or by special equipment teams accounted for in lines "b" and "e" of the worksheet. However, installation of initial improvements such as fencing, signs, sophisticated leachate control systems, access road and dumping area construction, and unusually extensive grading normally would not be included in those estimates. The annual proration of these capital costs should be inserted in line "jj" of the worksheet. Also, if leachate control systems are installed, an additional amount should be included in the operations cost estimate for their operation.

IV. ESTIMATED COSTS, FISCAL YEAR 1974-75, COMPLETE MODIFIED LANDFILL SYSTEM Lane County, Oregon

The cost estimates presented in Table 17 were developed by the Lane County Solid Waste Division and represent an application of the technique described in this report to the twelve rural disposal sites in the Lane County system. Assumptions made with respect to anticipated waste volumes, distance between the site and base operations, speed of travel, etc., are substantially the same as for the transfer system outlined on page 15. Additionally, the Division staff assumed a scheduling arrangement that maximized efficiency of the roving crews used to work the various sites in the system.

As noted in Table 17, if Lane County were to operate all of its twelve rural waste disposal sites as modified landfills, operating costs--exclusive of site improvement depreciation and land costs--could be expected to amount to approximately $130,000 for the fiscal year 1973-74. The operating cost of a full transfer system was estimated to be about $161,000 for the same period (Table 6).

The unit cost comparisons shown in Table 18 suggest that operating a modified landfill system is much less expensive than a transfer system at the higher volume sites, although transfer is competetive at the lower volume sites. Ironically, modified landfill operating standards are less likely to be acceptable at these higher volume sites than they would be at the smaller locations. In Lane County, for example, there is some question as to whether any of the rural sites can be operated on a modified landfill basis and meet desired environmental quality standards.

Estimates of gasoline and diesel fuel consumption, presented in Table 19, indicate that the implementation of a transfer system to serve the twelve rural disposal sites in Lane County would require about 10,000 fewer gallons annually than would operation of a complete modified landfill system. These data are based upon the following average fuel consumption characteristics of equipment used in the two systems.

Modified Landfill System Equipment

Crawler tractor	6.0 gallons diesel per hour
Other equipment	5.0 gallons diesel per hour
Tractor and lowboy	5.5 miles per gallon diesel
Pickup truck	8.0 miles per gallon gasoline

Transfer System Equipment

Transfer tractor-trailer	5.5 miles per gallon diesel

Table 17

ESTIMATED ANNUAL OPERATING COSTS
LANE COUNTY MODIFIED LANDFILL SYSTEM
Fiscal Year 1973-74

Modified Landfill Site	Landfill Tractor Cost	Other Equipment Cost	Fire Truck Cost	Equipment Transport Cost	Total Equipment Cost	Equipment Operator Cost	Utility Labor Cost	Transit Time Cost	Overhead	Total Labor Cost	Contingency	Total Operating Cost
Veneta	$ 4,565	$ 4,324	$2,000	$ 1,600	$12,489	$ 5,914	$ 2,873	$1,189	$ 3,492	$13,468	$1,347	$ 27,304
Rattlesnake	3,931	3,729	1,750	1,504	10,914	5,089	2,446	1,142	3,037	11,714	1,171	23,800
McKenzie Bridge	1,354	1,269	725	1,114	4,462	1,752	1,332	763	1,346	5,194	519	10,175
Mohawk	1,764	1,601	900	845	5,110	2,288	1,505	616	1,543	5,952	595	11,658
Vida-Leaburg	1,512	1,418	800	947	4,676	1,957	1,396	669	1,408	5,430	543	10,649
Walton	749	620	250	755	2,373	969	815	491	796	3,072	307	5,752
Sharps Creek	749	620	400	1,053	2,822	969	815	741	884	3,409	341	6,572
Mapleton	1,512	1,418	800	433	4,163	1,957	1,396	312	1,283	4,948	495	9,605
London	749	620	375	1,053	2,797	969	815	741	884	3,409	341	6,547
Horton[a]	749	620	250	754	2,373	969	815	491	796	3,072	307	5,752
Low Pass[a]	749	620	250	754	2,373	969	815	491	796	3,072	307	5,752
Swisshome	749	620	250	993	2,611	969	815	602	835	3,222	322	6,156
TOTAL, RURAL LANE COUNTY	$19,131	$17,478	$8,750	$11,804	$57,163	$24,773	$15,840	$8,248	$17,101	$65,961	$6,596	$129,720

a. Combined in Transfer Operation, reported in Table 6 as "Horton" station.

Table 18

COMPARATIVE OPERATING COSTS PER CUBIC YARD
MODIFIED LANDFILL AND TRANSFER SYSTEMS
Lane County, Oregon
Fiscal Year 1973-74

Site	Annual Volume (Cubic Yards)	Operating Costs Per CY	
		Transfer	Modified Landfill
Veneta	40,000	$ 0.850	$ 0.683
Rattlesnake	35,000	0.836	0.680
Mohawk	18,000	0.867	0.648
Vida-Leaburg	16,000	0.897	0.666
Mapleton	16,000	1.040	0.600
McKenzie Bridge	14,500	1.117	0.702
Horton	5,000	) 1.080 (	1.150
Low Pass	5,000		1.150
Sharps Creek	8,000	0.843	0.822
London	7,500	0.860	0.873
Walton	5,000	1.039	1.150
Swisshome	5,000	1.121	1.150
AVERAGE, LANE COUNTY	177,000	$ 0.930	$ 0.733

Table 19

ANNUAL FUEL CONSUMPTION ESTIMATES
TRANSFER AND MODIFIED LANDFILL SYSTEMS COMPARED
Lane County, Oregon

Disposal Sites	Annual Consumption (gallons)		
	Transfer System	Modified Landfill System	
	Diesel	Diesel	Gasoline
Veneta	3,881	7,660	468
Rattlesnake	3,020	6,611	416
Mohawk	1,942	3,078	260
McKenzie Bridge	4,222	) 5,399	702
Vida-Leaburg	2,155		
London and Sharps Creek	2,768	3,319	708
Walton, Mapleton, Swisshome	6,047	5,846	858
Horton and Low Pass	1,896	3,139	585
TOTAL, RURAL LANE COUNTY	25,931	35,052	3,997